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RECOVERY POTENTIAL ASSESSMENT OF PUGNOSE MINNOW (*Opsopoeodus emiliae*) IN CANADA

Pugnose Minnow (Opsopoeodus emiliae). Illustration by Joe Tomelleri, reproduced with permission.

Figure 1. Distribution of Pugnose Minnow in Canada.

Context

In April 1985, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed the status of Pugnose Minnow (Opsopoeodus emiliae) and determined the designation to be Special Concern. In May 2000, the status was re-examined and confirmed by COSEWIC. The status was re-assessed in May 2012 at which time Pugnose Minnow was designated as Threatened. The reason provided for this designation is that, "This fish is a small-bodied species with a restricted and declining distribution that inhabits river, stream and lake habitats. The species is threatened by habitat loss, habitat degradation from nutrient and sediment loading, climate change and several invasive species. The overall level of threat has been assessed as high." Pugnose Minnow is currently listed as Special Concern on Schedule 1 of the Species at Risk Act (SARA).

A species Recovery Potential Assessment (RPA) process has been developed by Fisheries and Oceans Canada (DFO) Science to provide the information and scientific advice required to meet the various requirements of the SARA, such as the authorization to carry out activities that would otherwise violate the SARA as well as the development of recovery strategies. The scientific information also serves as advice to the Minister of DFO regarding the listing of the species under the SARA and is used when analyzing the socio-economic impacts of adding the species to the list as well as during subsequent consultations, where applicable. This assessment considers the scientific data available with which to assess the recovery potential of Pugnose Minnow in Canada.

April 2013

Canada

SUMMARY

- Pugnose Minnow is currently known to occur in two distinct areas of the Great Lakes basin: the Detroit River and Lake St. Clair and its tributaries. Historic Pugnose Minnow records exist for the Thames River and McDougall Drain (a tributary of the Thames River); however, this species has not been recorded from this system since 1968 and 1984, respectively.
- In Canada, adult Pugnose Minnow are most often found in warm, slow moving areas of turbid streams with little to no aquatic vegetation, over silt/clay substrates or slow moving side channels of larger rivers with abundant vegetation. Historically, Pugnose Minnow has been described as preferring clear, slow-moving, heavily vegetated habitat. It is believed that Pugnose Minnow are currently persisting in sub-optimal areas, as preferred habitat may no longer be available. Very little information exists related to Pugnose Minnow juvenile habitat preferences. Spawning is thought to occur from May to June in Canada.
- To achieve ~99% probability of persistence, given a 10% per generation chance of catastrophic decline (50% decline in population), requires ~6.4 million adult Pugnose Minnow and at least 73.2 ha of suitable habitat.
- To achieve ~95% probability of persistence, given a 10% per generation chance of catastrophic decline (50% decline in population), requires ~366,000 adult Pugnose Minnow and at least 4.2 ha of suitable habitat.
- Current available habitat is estimated at 6000 ha. The quality of this habitat is unknown.
- The threats thought to have the largest effect on the survival and persistence of Pugnose Minnow in Canada are related to turbidity and sediment loading, habitat alterations, and nutrient loading. Lesser threats that may be affecting the survival of Pugnose Minnow include altered coastal processes, invasive species, and incidental harvest, although the current knowledge on the level of impact that these threats may have on Pugnose Minnow is very limited.
- Population growth of Pugnose Minnow is most sensitive to changes in the survival of immature individuals or in fecundity. If the population is declining, it is also moderately sensitive to changes in adult survival.
- Current population abundance is unknown. Exact population trajectory is unknown but assumed to be declining.
- Despite concerted efforts to increase our knowledge of Pugnose Minnow in Canada, there are still a number of key sources of uncertainty for this species related to population abundance, distribution and structure, habitat preferences and to the factors limiting their existence, namely, fecundity, mortality, and growth patterns. Parameters for Pugnose Minnow population modeling were based on simulated life-history data and results should be revisited if new data are collected. Other uncertainties include habitat quality, and the frequency of catastrophic decline of Pugnose Minnow.

BACKGROUND

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) recommended that Pugnose Minnow (*Opsopoeodus emiliae*) be designated as a species of Special Concern in April 1985. This status was re-examined and confirmed in May 2000. In May 2012, Pugnose Minnow was designated as Threatened due its restricted and declining distribution. The species

is threatened by habitat loss, habitat degradation from nutrient and sediment loading, climate change and several invasive species. Pugnose Minnow is currently listed as Special Concern on Schedule 1 of the *Species at Risk Act* (SARA). When COSEWIC designates an aquatic species as Threatened or Endangered and the Governor in Council decides to list it, the Minister of Fisheries and Oceans Canada (DFO) is required by the SARA to undertake a number of actions. Many of these actions require scientific information such as the current status of the population, the threats to its survival and recovery, and the feasibility of its recovery. This scientific advice is developed through a Recovery Potential Assessment (RPA). This allows for the consideration of peer-reviewed scientific analyses in subsequent SARA processes, including permitting on harm and recovery planning. This RPA focuses on Pugnose Minnow populations in Canada, and is a summary of the conclusions and advice from a Canadian Science Advisory Secretariat peer-review meeting that occurred on 1 November 2012 in Burlington, Ontario. Two research documents, one providing background information on the species biology, habitat preferences, current status, threats and mitigations and alternatives (Bouvier and Mandrak 2013), and a second on allowable harm, population-based recovery targets, and habitat targets (Young and Koops 2013) provide an in-depth account of the information summarized below. Proceedings that document the activities and key discussions of the meeting are also available (DFO 2013). Please note that reference citations have been removed from the following document to minimize the length of the document. Complete reference citations are available at Bouvier and Mandrak (2013) and Young and Koops (2013).

Species Description and Identification

Pugnose Minnow is a small, slightly deep-bodied, silver fish that reaches an average maximum total length (TL) in Ontario of approximately 5 cm, and does not exceed 6.4 cm. The most distinct characteristics of Pugnose Minnow are a rounded snout, a very small, steeply upturned mouth, and a pale lower lip. Pugnose Minnow has large scales (35-41 lateral scales) and a dorsal fin with nine dorsal rays. Colouration includes a white belly, a pale yellow to olive green back, a prominent lateral stripe that starts at the snout and ends in a spot at the base of the caudal fin, and darkly outlined scales, which give the appearance of a crosshatched pattern. Spawning males tend to have a darker dorsal fin, and the lower half of the anal fin is bright white. Spawning males may also have stubble-like nuptial tubercles on their snout, lips, and chin.

Pugnose Minnow is morphologically similar to other minnows, primarily Golden Shiner (*Notemigonus crysoleucas*) and Pugnose Shiner (*Notropis anogenus*). Golden Shiner may be distinguished from Pugnose Minnow by having a body that is deeper and thinner from side to side, and a large anal fin with more than 11 rays. Characteristics used to distinguish Pugnose Shiner from Pugnose Minnow include a dark lower lip, a dorsal fin with eight fin rays, and non-outlined scales that do not form a crosshatched pattern.

ASSESSMENT

Current Species Status

In Canada, current Pugnose Minnow distribution is restricted to southwestern Ontario where it is found in the Detroit River, Lake St. Clair proper, as well as tributaries of Lake St. Clair (Figure 1). Tributaries of Lake St. Clair include the Sydenham River (north and east branches), Bear Creek (a tributary of the North Sydenham River), East Otter Creek (a tributary of the East Sydenham River), Chenail Ecarte (a man-made connecting channel between St. Clair River and Lake St. Clair), and Little Bear Creek, Maxwell Creek, and Whitebread Drain, which all flow into the Chenail Ecarte.

Historically, Pugnose Minnow was present in both the Thames River and McDougall Drain (a tributary of the Thames River). Currently, Pugnose Minnow is considered extirpated from the Thames River and likely extirpated from McDougall Drain. The loss of these two populations has dramatically affected the distribution of this species resulting in an 87% decline in the extent of occurrence. The current area of occupancy, based on a 2 x 2 km grid, is 84 km² and when compared to the historic calculated area of occupancy (276 km²), represents a 69% decline for this species (COSEWIC 2012).

Detroit River

Pugnose Minnow was originally captured in the Detroit River near Fighting Island in 1940, consisting of two voucher specimens. Three additional voucher specimens were collected from this area in 1941. In 1994-1996, the ROM surveyed this area and confirmed the presence of Pugnose Minnow in the Detroit River. An additional 28 individuals were captured in 1994 from the Canard River (a tributary of the Detroit River). More recent collections confirmed the presence of Pugnose Minnow in this area with the collection of a single individual. It should be noted that intensive sampling has occurred in the Detroit River in 2003 and 2004, at numerous sites, with multiple gear types and a single individual was captured. This would lead us to believe that Pugnose Minnow, although present in the Detroit River, are very rare.

Lake St. Clair and tributaries

Lake St. Clair

The first record of Pugnose Minnow in Canada originates from Mitchell's Bay in Lake St. Clair in 1935 when two individuals were captured. Since this initial record, only three additional individuals have been captured from Lake St. Clair proper. Two additional individuals were captured from Mitchell's Bay near the location of the original capture in 1979, while a third individual was captured from the south shore of Lake St. Clair in 2007.

Comprehensive sampling has occurred on Walpole Island, the nearshore area of Mitchell's Bay, St. Clair National Wildlife Area, and the south shore of Lake St. Clair. Although these surveys did not exclusively use seine nets (the sampling technique commonly thought to be most effective at capturing Pugnose Minnow), Pugnose Minnow was not recorded from any of these surveys.

Sydenham River

Historically, Pugnose Minnow was first recorded from the Sydenham River in 1972 approximately 12.1 km north of Wallaceburg. Again, Pugnose Minnow was recorded from the North Sydenham River in 1978 and 1979. The two sites of capture were 5.5 km and 10 km north of Wallaceburg. The most recent Pugnose Minnow record from the North Sydenham River dates to 2003 when a single Pugnose Minnow was captured by backpack electrofisher. Attempts to capture Pugnose Minnow were made in 2010 when six sites were seined. Unfortunately, none of these attempts resulted in the capture of Pugnose Minnow.

Pugnose Minnow was first recorded from the East Sydenham River in 1979. Subsequent years of capture include 1997 (n=17), 2001 (n=1) and 2003 (n=3). More recently, 21 Pugnose Minnow were captured during targeted sampling in 2010 at five sites in the lower portion of the Sydenham River. It should be noted that although the status report reported the capture of 22 individuals, following verification of voucher specimens one of the vouchers was determined to be un-identifiable.

A total of 75 wadeable sites were sampling from 2003 to 2004 throughout the Sydenham River basin (north, and east branches) using multiple gear types (backpack electrofisher, seine,

minnow trap, and Windermere trap). This intensive sampling did not yield the capture of any Pugnose Minnow.

Bear Creek

A single Pugnose Minnow voucher has been collected from Bear Creek. The voucher was collected 100 m upstream from the confluence of Bear Creek and North Sydenham River. This is the only record of Pugnose Minnow from this tributary of the North Sydenham River.

East Otter Creek

A single Pugnose Minnow record exists for East Otter Creek (a tributary of the Sydenham River). The site was revisited and sampled in 2010 but no additional Pugnose Minnow were captured.

Chenail Ecarte

Five Pugnose Minnow have been captured from the Chenail Ecarte, a man-made connecting channel between the St. Clair River and Lake St. Clair. The first record was represented by the capture of a single individual in 1993. An additional four individuals were captured from two sites in 2010.

Maxwell Creek

Pugnose Minnow was initially recorded from Maxwell Creek (a tributary to Lake St. Clair) in 1974 (n=24). Unfortunately, the coordinates recorded with the voucher specimens were incorrect and the exact location of capture could not be determined. Additional voucher specimens were taken from Maxwell Creek in 1982 (n=1), 1996 (n=2), and in 2003 (n=2). Although the capture of Pugnose Minnow in 2010 was reported in the COSEWIC status report, this voucher specimen was verified to be Pugnose Shiner.

Little Bear Creek

Pugnose Minnow has been recorded from Little Bear Creek since 1982 (n=1). One additional individual was captured in 1996. In 2003, three individuals were recorded from four sites sampled by seine net. The site was re-visited in 2010 and an additional 11 individuals were recorded and verified. A slight correction should be made in the number of individuals captured reported in the COSEWIC status report, in that four of the 15 individuals originally reported were later verified to be Blacknose Shiner (*Notropis heterolepis*).

Whitebread Drain

Pugnose Minnow was first observed in Whitebread Drain (a small agricultural drain, which drains directly into the Chenail Ecarte) in 2003. The site was re-visited in 2010 and sampled with appropriate gear in search for additional individuals. No Pugnose Minnow were recorded from a single seine event.

McDougall Drain

Pugnose Minnow has also been recorded from a tributary to the Thames River, McDougall Drain. Two individuals were captured from McDougall Drain in 1984. McDougall Drain was re-visited in 2004 and Pugnose Minnow targeted sampling was undertaken. This targeted sampling did not result in the capture of any additional individuals. In addition, a single site was sampled in 2004 by the Upper Thames Region Conservation Authority and did not yield the capture of any Pugnose Minnow.

Thames River

Seven Pugnose Minnow voucher specimens originate from the Thames River. These vouchers were captured in 1968 near Delaware. Additional sampling, including sampling targeting Pugnose Minnow, has occurred since 1968 in the vicinity of the original capture location but has not resulted in the capture of additional individuals. A lack of Pugnose Minnow captures despite substantial effort using the appropriate gear in habitats thought to be preferred by Pugnose Minnow leads us to believe that Pugnose Minnow is extirpated from the Thames River.

Population Status Assessment

To assess the population status of Pugnose Minnow in Canada, each population was ranked in terms of its abundance and trajectory. The level of certainty was associated with each assignment (1=quantitative analysis; 2=CPUE or standardized sampling; 3=expert opinion). The Abundance Index and Population Trajectory values were combined in the Population Status matrix to determine the Population Status for each population. Each Population Status was subsequently ranked as Poor, Fair, Good, Unknown or Extirpated (Table 1). The Certainty assigned to each Population Status is reflective of the lowest level of certainty associated with either initial parameter. For the purposes of the RPA, Lake St. Clair and its tributaries are considered a single population. This determination follows the RPA definition of a population, in that if no barriers to movement exist, if there is similar or continuous occupied habitat connecting the two locations, and the species could conceivably move from one location to another, these individuals are considered to be a part of a single population. Refer to Bouvier and Mandrak (2013) for detailed methods used for the assessment of Population Status.

Table 1. Population Status of all Pugnose Minnow populations in Canada, resulting from an analysis of both the Abundance Index and Population Trajectory. Certainty assigned to each Population Status is reflective of the lowest level of certainty associated with either initial parameter (Abundance Index, or Population Trajectory).

Population	Population Status	Certainty
Detroit River	Poor	3
Lake St. Clair and tributaries	Poor	3
McDougall Drain	Likely extirpated	2
Thames River	Extirpated	2

Habitat Requirements

Spawning

Spawning habitat preferences and spawning behaviour of Canadian populations of Pugnose Minnow are not known. Spawning season has been recorded for Pugnose Minnow in Florida (late winter into late summer), Illinois (spawning fish collected in May to June), Missouri (fish caught in spawning condition late-May to June), and Texas (May to June). Based on specimen size, it has been suggested that the spawning season in Texas may begin as early as February. It is difficult to infer the spawning season for Canadian populations of Pugnose Minnow based on this information, but there is general agreement that spawning likely occurs in the spring (May to June). There is a record of a single pre-spawn female captured from an unnamed drain to Mitchell's Bay on June 2, 1979 when water temperature was recorded to be 21°C.

Spawning has been observed in a laboratory setting with fish collected from creeks in Louisiana and Alabama. The following is a synopsis of the spawning behaviour observed during Page and Johnston's (1990) aquaria-based spawning experiment. Aquaria were set up with substrate known to be used for spawning by North American minnows (i.e., sand, fine gravel, coarse gravel), as well as vegetation, logs, and rocks ranging in size from boulders to a piece of slab. In all experiments (n=2), a dominant male selected the underside of a large rock as the spawning surface. The male prepared the site for egg deposition, and 87 spawning acts were observed. Males selectively chose the underside of a large rock, although many other potential spawning surfaces were readily available indicating a preference to this type of substrate for spawning. Eggs were collected and placed in holding containers with various water temperatures. All eggs held at 11, 16, and 29°C died, while all eggs held at 21, 25, and 27°C hatched, indicating a likely temperature range preference for egg hatching of 21-27°C. Newly hatched larvae were 5-5.5 mm in length (total or standard length was not specified).

Larval & Juvenile

There is very limited information available on habitat preferences of juvenile Pugnose Minnow. Limited data on juvenile Pugnose Minnow habitat requirements necessitate the inference of these requirements from other, better-studied, life stages.

Adult

Very little information is available regarding the habitat requirements of Pugnose Minnow in Canada. Data recorded with vouchers captured from the North Sydenham River during surveys described habitat as pond-like, weedy embayments along the river's edges. Water depth was recorded between 0.5 and 1.5 m, and a high level of suspended solids, resulting in a maximum Secchi disc transparency of approximately 10 cm, was noted from all capture locations. During this September survey, Pugnose Minnow was captured when water temperatures ranged from 17.5 to 19°C, and dissolved oxygen concentrations were approximately 7 mg/L. Capture locations in Mitchell's Bay (embayment of Lake St. Clair) varied slightly, in that aquatic vegetation was present, and heavy growth of spatterdock (*Nuphar* sp.) was noted at several sites of capture. It was also noted that water transparency was higher in Mitchell's Bay, although values were not provided. It was concluded that the high turbidity at capture sites during the 1979 survey suggested that the North Sydenham River system may provide only marginal habitat for this species, and that Mitchell Bay may provide a more favourable habitat.

Pugnose Minnow vouchers captured during surveys completed in 1996-1997 include descriptions of habitat characteristics similar to those described above. Secchi depth at points of capture ranged from 0.1 – 0.3 m and substrate composition was described as silt, muck and detritus with some cover of boulders, woody debris, and aquatic vegetation.

Habitat information at point of capture was available for all 2003 (n=28) and 2010 (n=36) DFO records. Pugnose Minnow was captured in relatively shallow water with depth ranging from 0.42 to 1.34 m. Pugnose Minnow was also captured from environments exhibiting a broad spectrum of water temperature, ranging from 13.9 to 29.0°C. Turbidity was measured with either a Secchi disc (readings ranged from 0.28 to 1.8 m; mean=0.58 m) or turbidity tube (readings ranged from 0.22 to 0.64 m; mean=0.41 m). The majority of sites were classified as having a silt/clay-dominant substrate. Most sites were also classified as being dominated by open water (n=8), while sites dominated by submergent (n=5) or floating (n=2) macrophytes were also quite common. This association with open water-dominated habitat is contrary to most published literature suggesting a strong relationship between Pugnose Minnow and high macrophyte abundance. However, specimens recorded from the Chenail Ecarte and Detroit River were associated with areas containing abundant vegetation.

Although this species has been historically described as preferring clear, slow-moving, heavily vegetated habitat, currently Pugnose Minnow in Canada are most often found in warm, slow moving areas of turbid streams with little to no aquatic vegetation, over silt/clay substrates or slow moving side channels of larger rivers with abundant vegetation. Trautman (1981) describes the contradictory habitat characteristics for Ohio populations of Pugnose Minnow. Relict Pugnose Minnow populations persisted in Ohio for several years after almost all of the aquatic vegetation had disappeared, and after turbidity levels and siltation had become high. He believed that small populations may persist for some time in submarginal conditions when preferred habitat is no longer available. This persistence in areas of sub-optimal habitat may describe the current state of Pugnose Minnow in Canada and may also explain the few individuals captured despite targeted sampling efforts.

Functions, Features and Attributes

A description of the functions, features, and attributes associated with Pugnose Minnow habitat can be found in Table 2. Please see Bouvier and Mandrak (2013) for definitions of functions, features and attributes. Habitat attributes from the literature for each life stage have been combined with habitat attributes from current records (records from 2002 to present) to show the maximum range in habitat attributes within which Pugnose Minnow may be found. This information is provided to guide any future identification of critical habitat for this species. It should be noted that habitat attributes associated with current records may differ from the habitat attributes described in the literature as Pugnose Minnow may be occupying sub-optimal habitat in areas where optimal habitat is no longer available.

Residence

Residence is defined in SARA as a, "dwelling-place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating". Residence is interpreted by DFO as being constructed by the organism. In the context of the above narrative description of habitat requirements during larval, juvenile and adult life stages,

Pugnose Minnow does not construct residences during its life cycle.

Table 2. Summary of the essential functions, features and attributes for each life stage of Pugnose Minnow. Habitat attributes from published literature, and habitat attributes recorded during recent Pugnose Minnow surveys (captured over the last 10 years or since 2002) have been combined to derive the habitat attributes required for the delineation of critical habitat (see text for a detailed description of categories).

			Habitat Attributes		
Life Stage	**Function**	**Feature(s)**	**Scientific Literature**	**Current Records**	**For Identification of Critical Habitat**
Spawning	Reproduction (spawning likely occurs May to June) Nursery	Slow moving areas of streams or slow moving side channels of larger rivers.	• Laboratory - Males selectively chose the underside of a large rock, although many other potential spawning surfaces were readily available indicating a preference to this type of substrate for spawning (Page and Johnston 1990)		• Appropriate horizontal surfaces
Juvenile (hatch to age 1)	Feeding Cover	Slow moving areas of streams or slow moving side channels of larger rivers.			• Same habitat as adults
Adult (from age 1 [onset of sexual maturity])	Feeding Cover	Slow moving areas of streams or slow moving side channels of larger rivers.	**Water depth** • Water depth was recorded between 0.5-1.5 m (Parker et al. 1987)	• Shallow water with depth ranging from 0.42 to 1.34 m (DFO, unpubl. data)	• Areas of shallow water, ranging from 0.42 to 1.5 m.
			Turbidity • Described as preferring clear water habitats (Gilbert and Bailey 1972; Scott and Crossman 1973; Trautman 1981) • High level of suspended solids, (maximum Secchi disc of approx. 10 cm) (Parker and McKee 1980) • Secchi depth at points of capture ranged from 0.1 – 0.3 m (ROM unpubl. data in COSEWIC draft)	• Turbidity was measured with either a Secchi disc (readings ranged from 0.28 to 1.8 m) or turbidity tube (readings ranged from 0.22 to 0.64 m) (DFO, unpubl. data)	
			Vegetation • Vouchers captured from the North Sydenham River described habitat as weedy embayments (Parker and McKee 1980) • Capture locations in Mitchell's Bay indicated aquatic vegetation was present, and heavy growth of spatterdock was noted at several sites of capture (Parker and McKee 1980)	• Most sites were classified as being dominated by open water (n=8), while sites dominated by submergent (n=5) or floating (n=2) macrophytes were also quite common (DFO, unpubl. data) • Specimens recorded from Chenail Ecarte and Detroit River were associated with abundant vegetation (DFO, unpubl. data)	

Recovery Modeling

Population Sensitivity

The assessment of population sensitivity involves perturbation analyses of population projection matrices, and includes a stochastic element. Outputs of the analyses include calculation of a population growth rate and its sensitivity to changes in vital rates. Life history data for Pugnose Minnow is largely unknown; parameters for Pugnose Minnow population modeling were based on simulated life-history data and should be revisited if new data are collected. See Young and Koops (2013) for complete details of the model and results. Population growth of Pugnose Minnow is very sensitive to perturbations of YOY survival and fecundity (Figure 2). The population is much less sensitive to changes in adult survival.

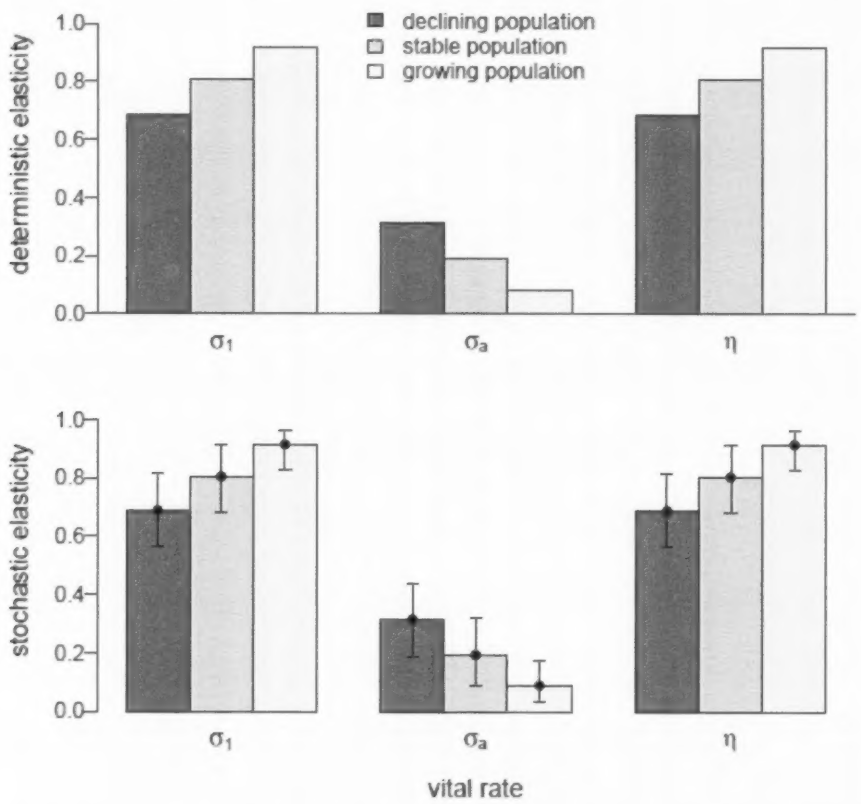

Figure 2. Results of the deterministic (panel 1) and stochastic (panel 2) perturbation analysis showing elasticities (ε_v) of vital rates for Pugnose Minnow: annual survival probability of YOY (σ_1), adults (σ_a), and fertility (η). Stochastic results include associated bootstrapped 95% confidence interval.

Allowable Harm

For the purpose of the recovery potential assessment modelling, the following definitions are used:

- Allowable harm is defined as harm to the population that will not jeopardize population recovery or survival.
- Chronic harm refers to a negative alteration to a vital rate that reduces a population growth rate over the long term.

- Transient harm refers to a one-time removal of individuals that reduces the mean population growth rate temporarily over a specific time frame.

Using the current estimated population growth rate, allowable chronic harm is determined such that said harm to the vital rate(s) of Pugnose Minnow does not cause population decline. Allowable transient harm is defined as an acceptable temporary change in growth rate resulting from one-time removals of individuals over 10 years or 3 generations, whichever is shorter (4 years for Pugnose Minnow). The allowable removal rate is determined by simulating removal of individuals (stochastically) and measuring the change in population growth rate.

Current population abundance of Pugnose Minnow is unknown. Exact population trajectory is unknown but assumed to be declining. Therefore, allowable chronic and transient harm are not provided for the Pugnose Minnow. Figure 3 shows the effect of transient harm on the population growth of Pugnose Minnow

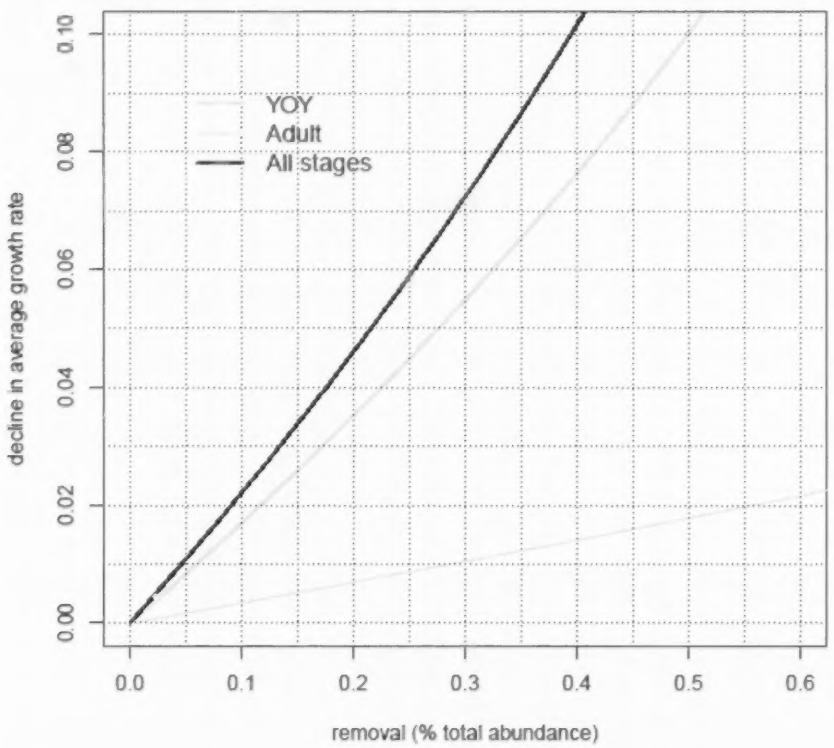

Figure 3. Decline in average population growth rate over 4 years, as a function of the percent of individuals removed from the population in one of 4 years. Results for removal of YOY only, adults only, or all stages are compared. Values shown are the lower confidence bounds from Figure 4 in Young and Koops (2013). Allowable transient harm can be determined from these curves based on the acceptable decline in average population growth rate.

Summary of Science Advice on Allowable Harm

Each element of allowable harm advice is independent and assumes no additional sources of harm. If there is harm from multiple sources, allowable harm should be reduced.

Allowable Chronic Harm

- When population trajectory is declining, there is no scope for allowable chronic harm (at the population level).
- When population trajectory is stable and exceeds the recovery target (MVP) then chronic harm may be considered that does not result in a decline of the population growth rate.
- When population trajectory is unknown, the scope for allowable chronic harm can only be assessed once population data are collected.
- Scientific research to advance the knowledge of population data should be allowed.

Allowable Transient Harm

- When population trajectory is declining or unknown, even low levels of transient harm may compromise recovery or shorten the time to extirpation.
- When population trajectory is increasing, there is scope for allowable transient harm.
- When population abundance is unknown, the scope for allowable transient harm can only be assessed once population data are collected.

Recovery targets

Demographic sustainability was used as a criterion to set recovery targets for Pugnose Minnow. Demographic sustainability is related to the concept of a minimum viable population (MVP; Shaffer 1981), and was defined as the minimum adult population size that results in a desired probability of persistence over 100 years (approximately 83 generations). MVP targets were chosen to optimize the benefit of reduced extinction risk and the cost of increased recovery effort, and resulted in a persistence probability of approximately 99% over 100 years. Recommended targets were estimated at ~6.4 million adults (ages 1+), assuming the probability of a catastrophic (50%) decline was 0.10 per generation and an extinction threshold of two adults.

Minimum Area for Population Viability

Minimum area for population viability (MAPV) is a quantification of the amount of habitat required to support a viable population. Variables included in the MAPV assessment include MVP values and area required per individual (API values). API values were estimated from an allometry for river environments from freshwater fishes. MAPV for the recommended recovered population above was 73.2 ha of suitable Pugnose Minnow habitat. Current available habitat is estimated at 6000 ha. The quality of this habitat is unknown.

Threats to Survival and Recovery

A wide variety of threats negatively impact Pugnose Minnow across its range. Our knowledge of threat impacts on Pugnose Minnow populations is limited to general documentation, as there is a paucity of threat-specific cause and effect information in the literature. The threats thought to have the largest effect on the survival and persistence of Pugnose Minnow in Canada are related to turbidity and sediment loading, habitat alterations, and nutrient loading. Lesser threats that may be affecting the survival of Pugnose Minnow include altered coastal processes, invasive species, and incidental harvest. In Ontario rivers, numerous activities are known to negatively affect fish habitat; however, those most commonly linked to the destruction and degradation of Pugnose Minnow habitat relate to agricultural and urban development, and result in increased turbidity, sediment

loading, and siltation, increased levels of contaminants and toxic substances, and increases in nutrient loading. River and lake shoreline modifications can lead to altered flow regimes and coastal processes resulting in the loss of Pugnose Minnow preferred habitat. It is important to note the threats discussed below may not always act independently on Pugnose Minnow populations; rather, one threat may directly affect another, or the interaction between two threats may introduce an interaction effect on Pugnose Minnow populations. It is difficult to quantify these interactions; therefore, each threat is discussed independently.

Threat Level Assessment

To assess the Threat Level of Pugnose Minnow population, each threat was ranked in terms of the Threat Likelihood and Threat Impact on a population basis (see Bouvier and Mandrak 2013 for complete details on classification approach). Threat Impact categorization was assigned on a location-by-location basis. If no information was available on the Threat Impact at a specific location, a precautionary approach was used - the highest level of impact from all sites was applied. The Threat Likelihood and Threat Impact for each population were subsequently combined in the Threat Status Matrix resulting in the final Threat Status for each location (Table 3). Certainty has been classified for Threat Impact and is based on: 1= causative studies; 2=correlative studies; and, 3=expert opinion [level of certainty listed from highest (1) to lowest (3)].

Table 3. Threat Level for all Pugnose Minnow populations in Canada, resulting from an analysis of both the Threat Likelihood and Threat Impact. The number in brackets represents the level of Certainty assigned to the Threat Impact and was classified as: 1=causative studies; 2=correlative studies; and 3=expert opinion.

Threats	Lake St. Clair and tributaries	Detroit River
Turbidity and sediment loading	High (3)	Medium (3)
Nutrient loading	High (3)	Medium (3)
Habitat alteration	High (3)	High (3)
Contaminants and toxic substances	High (3)	High (3)
Invasive species	Low (3)	Low (3)
Incidental harvest	Low (1)	Low (1)

Mitigations and Alternatives

Threats to species survival and recovery can be reduced by implementing mitigation measures to reduce or eliminate potential harmful effects that could result from works or undertakings associated with projects, or activities in Pugnose Minnow habitat. Although currently recognized as a species of Special Concern on Schedule 1 of the SARA, prohibitions do not apply to Pugnose Minnow. In Ontario, the species is listed as Threatened under the *Endangered Species Act 2007*, which necessitates the preparation of a formal provincial recovery strategy for Pugnose Minnow to manage the species and prevent further decline. Legislation exists to prevent the intentional harvest of Pugnose Minnow as bait; however, due to its morphological similarity to other cyprinids, it may be inadvertently taken. Pugnose Minnow has previously been identified and included in the Sydenham River recovery plan.

Within Pugnose Minnow habitat, a variety of works, undertakings, and activities have occurred that have directly or indirectly affected Pugnose Minnow habitat (please see Bouvier and Mandrak 2013 for a complete list of works, undertakings, and activities). Research has been completed

summarizing the types of work, activity, or project that have been undertaken in habitat known to be occupied by Pugnose Minnow (Table 4).

Based on the assumption that historic and anticipated development pressures are likely to be similar, it is expected that comparable projects and activities will likely occur in Pugnose Minnow habitat in the future. There was an increased frequency of works in the categories of water crossings and the placement of structures in water (i.e., docks). Research also indicated that the primary project proponents were individual landowners.

As indicated in the Threat Analysis, numerous threats affecting Pugnose Minnow populations are related to habitat loss or degradation. Habitat-related threats to Pugnose Minnow have been linked to the Pathways of Effects developed by DFO Fish Habitat Management (FHM) (Table 4). DFO FHM has developed guidance on mitigation measures for 19 Pathways of Effects for the protection of aquatic species at risk in the Central and Arctic Region (Coker et al. 2010). This guidance should be referred to when considering mitigation and alternative strategies for habitat-related threats.

Table 4. Summary of works, projects and activities that have occurred during the period of August 2009 to August 2011 in areas known to be occupied by Pugnose Minnow. Threats known to be associated with these types of works, projects, and activities have been indicated by a checkmark. The number of works, projects, and activities associated with each Pugnose Minnow population, as determined from the project assessment analysis, has been provided. Applicable Pathways of Effects have been indicated for each threat associated with a work, project or activity (1 - Vegetation clearing; 2 – Grading; 3 –Excavation; 4 – Use of explosives; 5 – Use of industrial equipment; 6 – Cleaning or maintenance of bridges or other structures; 7 – Riparian planting; 8 – Streamside livestock grazing; 9 – Marine seismic surveys; 10 – Placement of material or structures in water; 11 – Dredging; 12 – Water extraction; 13 – Organic debris management; 14 – Wastewater management; 15 – Addition or removal of aquatic vegetation; 16 – Change in timing, duration and frequency of flow; 17 – Fish passage issues; 18 – Structure removal; 19 – Placement of marine finfish aquaculture site).

Work/Project/Activity	**Threats** (associated with work/project/activity)						**Watercourse/Waterbody** (number of works/projects/activities between 2009-2011)	
	Turbidity and sediment loading	**Nutrient loading**	**Habitat alterations**	**Contaminants & toxic substances**	**Invasive species**	**Incidental harvest**	**Detroit River**	**Lake St. Clair and tributaries**
Applicable pathways of effects for threat mitigation and project alternatives	1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 15, 16, 18	1, 4, 7, 8, 11, 12, 13, 14, 15, 16	1, 2, 3, 4, 5, 7, 8, 10, 11, 12, 13, 14, 15, 16, 18	1, 4, 5 ,6 ,7, 11, 12, 13, 14, 15, 16, 18				
Water crossings (e.g., bridges, culverts, open cut crossings)	✓			✓			1	15
Shoreline, streambank work (e.g., stabilization, infilling, retaining walls, riparian vegetation management)	✓			✓			6	1
Dams, barriers (e.g., maintenance, flow modification, hydro retrofits)	✓				✓			
Instream works (e.g., channel maintenance, restoration, modifications, realignments, dredging, aquatic vegetation removal)	✓	✓		✓			1	4
Water management (e.g., stormwater management, water withdrawal)	✓	✓		✓				3
Structures in water (e.g., boat launches, docks, effluent outfalls, water intakes)	✓	✓		✓			11	2
Baitfishing						✓		
Invasive species introductions (authorized and unauthorized)					✓			

Additional mitigation and alternative measures, specific to the Pugnose Minnow, related to invasive species and incidental harvest are listed below.

Invasive Species

As discussed in the **THREATS** section, aquatic invasive species (e.g., Common Carp, *Cyprinus carpio*) introduction and establishment could have negative effects on Pugnose Minnow populations. Mitigation and alternatives should not only be considered for current established invasive species but species that may invade in the future.

Mitigation

- Physically remove non-native species from areas known to be inhabited by Pugnose Minnow.
- Monitor watersheds for invasive species that may negatively affect Pugnose Minnow populations directly, or negatively affect Pugnose Minnow habitat.
- Develop a plan to address potential risks, impacts, and proposed actions if monitoring detects the arrival or establishment of an invasive species.
- Introduce a public awareness campaign and encourage the use of existing invasive species reporting systems.

Alternatives

- Unauthorized
  - None.
- Authorized
  - Use only native species.
  - Follow the National Code on Introductions and Transfers of Aquatic Organisms for all aquatic organism introductions (DFO 2003).

Incidental Harvest

As discussed in the **THREATS** section, incidental harvest of Pugnose Minnow through the baitfish industry was recognized as a potentially low risk threat.

Mitigation

- Provide information and education to bait harvesters on Pugnose Minnow to raise awareness, and request the voluntary avoidance of areas occupied by Pugnose Minnow.
- Provide recommendations on timing windows as to when incidental harvest of Pugnose Minnow would have the greatest effect on the population (e.g., spawning season)
- Immediate release of Pugnose Minnow if incidentally caught, as defined under the Ontario Recreational Fishing Regulations (Ontario Ministry of Natural Resources 2012).
- Education through mandatory training on species at risk for baitfish harvesters.

Alternatives

- Prohibit the harvest of baitfish in areas where Pugnose Minnow is known to exist.

If Pugnose Minnow is listed as Threatened under the SARA, it is possible that alternatives in addition to mitigation will be required. However, alternatives, such as redesigning projects, have also been used as mitigations in many of the works that have taken place in the last few years.

Sources of Uncertainty

Despite concerted efforts to increase our knowledge of Pugnose Minnow in Canada, there are still a number of key sources of uncertainty for this species related to population distribution and structure, habitat preferences and to the factors limiting their existence.

Information on population size, current trajectory, and trends over time in areas where Pugnose Minnow is known to occur is limited; therefore, there is a need for a continuation of quantitative sampling. There is also a need for additional targeted sampling in McDougall Drain to confirm that this population is extirpated, as it is currently assessed as 'likely extirpated' in the population status assessment. Additional targeted sampling at known sites of capture should be completed to determine population sizes. Additional sampling is necessary for all populations that were assigned a low certainty in completing the population status assessment. These baseline data are required to monitor Pugnose Minnow distribution and population trends as well as the success of any recovery measures implemented. There is a need to explore novel sampling methods to capture Pugnose Minnow. Traditional sampling methods, seine netting, may not be appropriate for this species, and may help explain low capture numbers despite targeted efforts. If Pugnose Minnow can be successfully captured, there is a need to determine abundance estimates to properly interpret population modelling (see Young and Koops 2013). Certain life history characteristics, also required to inform Pugnose Minnow population modelling efforts, are currently unknown. Studies to validate age of maturation, growth, and longevity of Pugnose Minnow in Canada are required. Further studies should focus on acquiring additional information on fecundity, and population growth rate. Additional unknowns for this species include their ability to hybridize with other closely related species, and sex ratios.

Very little information is available regarding the habitat requirements of Pugnose Minnow in Canada. There is a need to identify habitat requirements for each life stage. Although it is currently assumed that individuals from all Pugnose Minnow life stages occupy the same functional habitat, this assumption should be verified through sampling. This may also allow us to gain a better understanding of preferred habitat of juvenile Pugnose Minnow. Larval surveys are needed to identify nursery grounds. Spawning habitat and spawning behaviour of Canadian populations of Pugnose Minnow are not well known. It is difficult to infer the spawning season for Canadian populations of Pugnose Minnow based on the limited information available from populations found in the United States. Descriptions of Pugnose Minnow preferred habitat from the literature appear to contradict habitat descriptions recorded from areas where Pugnose Minnow has recently been captured in Canada (see Habitat Requirements section for additional information). The contradictory descriptions may be best explained by the theory that Pugnose Minnow in Canada are currently persisting in sub-optimal habitats because their preferred habitat has been lost to habitat degradation. This persistence in areas of sub-optimal habitat may also be used to explain why so few individuals have been captured despite concerted, targeted sampling efforts. There is a need to further investigate the relationship between the lack of population information, and the wider than expected range of habitat being used. It is important to determine expected Pugnose Minnow habitat for Canada to further inform targeted sampling.

Numerous threats have been identified for Pugnose Minnow populations in Canada, although the direct impact that these threats might have is currently unknown. There is a need for more causative studies to evaluate the direct impact of each threat on Pugnose Minnow populations with greater certainty. In the literature, the threat impacts are generally discussed at a broad level (i.e., fish assemblage level). There is a need to determine threshold levels for water quality parameters (e.g., nutrients, turbidity). The frequency and impact of toxic spill events on Pugnose Minnow is an additional source of uncertainty. In addition, the effect of invasive species, other than those discussed above, on Pugnose Minnow populations is currently unknown. Bycatch of

Pugnose Minnow during angler harvest of bait is currently unknown due to uncertain angler practices. Should bycatch occur, the ability of harvesters to sort and remove Pugnose Minnow from target catches is unknown.

SOURCES OF INFORMATION

This Science Advisory Report is from the November 1, 2012 Recovery Potential Assessment of Pugnose Minnow (*Opsopoeodus emiliae*). Additional publications from this process will be posted as they become available on the DFO Science Advisory Schedule at http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm.

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FOR MORE INFORMATION

Contact: Lynn Bouvier
Great Lakes Laboratory for Fisheries and Aquatic Sciences
Fisheries and Oceans Canada
867 Lakeshore Road
Burlington, Ontario L7R 4A6

Tel: 905-336-4863

E-Mail: Lynn.Bouvier@dfo-mpo.gc.ca

This report is available from the:

Centre for Science Advice (CSA)
Central and Arctic Region
Fisheries and Oceans Canada
501 University Crescent
Winnipeg, Manitoba
R3T 2N6

Telephone: (204) 983-5131
E-Mail: xcna-csa-cas@dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas-sccs/

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